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Seed factor in the management of ranges

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THE SEED FACTOR

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Introduction

Grasslands of the old world developed historical importance only after the domestication of cattle, sheep, goats and horses. Domesticated cattle existed in Egypt in 3500 B. C., and possibly as early as the beginning of the history of civilization. The raising of livestock was one of the more important means of early man's livelihood, pastural nomads having vast herds of livestock that grazed on the grasslands of Europe, Asia and Africa. (8) (6: Vol. 16)

These nomadic people finally grouped themselves into small settlements, and since they had no definite systems of herding, the surrounding grassland country was soon denuded by overgrazing. In many cases entire towns were deserted because of the lack of forage for the herds of livestock. No cultivation of any sort was practiced by these people, and therefore artificial reseeding of natural range was unknown. Consequently, when the natural forage was destroyed, necessity forced the people to move on. (8) (6: Vol. 16)

The destruction of grazing lands in Europe can best be pointed out in England, France and Germany, where grazing rights were established as early as 1236. (3)

In England, except for a brief period of time, grazing has never been of outstanding importance. The increase in population and wealth in western Europe after 1485 created a greatly increased demand for woolen materials. Sheep grazing in England suddenly became a huge industry, and everything else was sacrificed for the sake of increasing grazing lands. Large tracts of land fell into the hands of individual owners, and grazing rights were established by constant usage. Year after year these areas were continuously grazed until they became denuded wastelands. Now the lands are too sterile for agriculture, being mostly heath covered wastes too poor for good grazing even if there were a demand for their product. (3) (8)

In France the history of grazing goes back almost a thousand years. The grazing interests, strongly intrenched with "vested rights", have long controlled the grazing lands of southern France. Under their unregulated domination, the pastures have suffered from overgrazing for generations, resulting in denudation and erosion over a large portion of the region. The French Government has spent billions of francs in an effort to stop this devastation. Its work has met with only partial success, however, largely because the grazing interests, intrenched legally and politically and apparently blind to the national welfare, have constantly checked every attempt to restrict their established rights. (3)

In Germany, as in England and France, grazing did not develop on a large scale, as it was considered a farming industry. The harm done by grazing in this case was on the forested areas where rights were established by long, unrestricted use of the land. (3)

Cato points out, in his book on Roman Farm Management, that systems of grazing were used to protect grazing lands as early as the first Roman history. (4) Flocks of sheep were driven long distances to summer ranges, as were cattle, horses and mules. The higher mountain ranges were used by the sheep during the summer and the lower plains areas in the winter. The intervening lands were grazed by the other classes of livestock. The extensive pastures of "Tavoliere di Puglia" were of great importance and have a history of their own. This vast domain covered one hundred fifty square miles, and its origin belongs to the time of the Roman Conquests. The wars of the republic were fought out on the plains, causing them to become deserted and uncultivated, fit for only public pastures in the wintertime. (4)

Systems of grazing to protect pastures have long been practiced in the Channel Islands, Denmark, where grazing animals were tethered to pegs fixed in the ground, and a system of rotation grazing developed for those small areas that were grazed from each peg. This system protected the forage and is still in use on these islands. (6: Vol. 10)

The people of the United States may well turn to the experiences of some of the older countries for advice on the question now confronting them--to what extent and under what conditions should grazing be permitted to insure permanent pastures on 700,000 square miles of public grazing lands in the West? This question is vitally important to us, as vast areas of the public domain and private ranges that once supported an abundance of forage are now waste lands. Over-stocking, year-long grazing and drouth conditions, taken individually or collectively, have been the cause of this denudation.

The history of livestock grazing in America begins with the landing of cattle, sheep and horses in Mexico about 1521. Coronado's expeditions mark, unquestionably, the year of 1540 as the date in which sheep and cattle first came into the southwestern United States. From Mexico the line of settlement spread in two directions; north along the Pacific Coast, and northeast into New Mexico, Arizona and Texas. From the various settlements of the Spanish, the livestock industry of the Southwest spread gradually, until it finally fused with that from the eastern portion of the United States. (10), (20) Livestock grazing along the Atlantic coast has always been of minor importance. There were a few large stock farms, all of which were in the South. As the East became more densely settled, these cattle herds were forced farther west. (5)

In the early seventies the East awoke to the opportunities offered for cattle and sheep raising upon the open ranges which lay west of the Mississippi river. Large cattle companies were formed there and in Europe. Hundreds of thousands of cattle were pushed into these new unstocked ranges, and gradually farther and farther out onto the prairies. The longhorns from the South and Southwest were driven east and north, until they met and mingled with the better breeds from the East. They spread over the entire region until by 1895 no open range remained unstocked. The ranges soon became over-stocked, and the native grasses gradually disappeared. It was impossible for the grazing lands to remain permanent when no blade of grass appeared above the ground without being clipped. (10), (2)

No provision was made for winter feed, and the dry, hot summer of 1886, followed by an extremely severe winter, caught the cattlemen unprepared to meet adverse conditions. As a result, cattle died by the thousands, and cattle companies went out of existence. Since that time the business of raising cattle upon open ranges has been a fluctuating one. (2)

In the early nineties after the passing of the big cattle companies, the sheepmen gained a foothold on the western ranges and further denuded them. The majority of these sheepmen were nomadic people who possessed no property except their bands of sheep. No one dared save an acre of grazing land for future use, as it would be sought out by some herder and his hungry band of stock.

By 1890 the injury to the western stock ranges had become marked, as their carrying capacity had been greatly reduced. Something had to be done to save the remaining ranges, and in 1891 the first forest reserves were established. When the forest reserves were placed under administration in 1897, the Government had to face the problem of controlling the grazing, which had been demonstrated to be injurious to grazing lands throughout the West under the current methods of handling stock. The success of regulated grazing on National Forests is outstanding. The reduction of damage by erosion, the improved condition of the livestock ranging on the forests, the certainty on the part of the permittee that he will be protected in the use of the range, and the resulting increase in the value of ranch property have all given stability to that portion of the livestock industry dependent upon

National Forest ranges. (1)

Generally speaking, the forest ranges are fully stocked, and constant and vigilant control of grazing is absolutely necessary to prevent injury. The moment there is a break in the efficiency of the supervision and inspection of the grazing, damage begins. Full utilization of the forage of the public forests is, therefore, possible only with an elastic system of control like that now in effect, as to permit constant adjustment of the grazing and other existing conditions on the ground.

The problem has to be investigated from every angle if full utilization is to be expected without injury to the forage. Very little is known of the germination per cent of our native forage grasses, nor what effect the environmental factors that affect plant growth have on seed germination. This problem is of vital importance to systematic range management. The only way that it can be studied is through germination tests of native grass seeds collected from as wide a range of habitats as possible during several successive years. No one worker could ever attempt a project on such a large scale. Therefore the United States Forest Service, Region One, in cooperation with the School of Forestry at the University of Montana, worked up a plan whereby the experiment could be successfully carried out for the benefit of both.

The grass seeds have been collected on the more important grazing forests of Montana and Idaho, namely Madison, Jefferson, Beaverhead, Gallatin, Absaroka, Beartooth, Custer, Lewis and Clark, Deerlodge, Clearwater and Nez Perce. Each year since 1926 the seeds have been collected and sent to the seed testing laboratory of the School of Forestry.

Object of the Study

The role of seed testing is to help the rancher and ranger determine to what extent he may pasture his grazing lands without injury to the future development of the plants or their seed producing capacity. The permanency of ranges is almost wholly dependent upon the propagation of the seeds of our native grasses. Since the germination per cent of the more important grass seeds is very low, any decrease in the strength of the plant or seeds will in the end seriously affect the forage producing ability of the ranges. The public domain in the western United States demonstrates the condition that occurs from the abusive use of range lands. Large tracts of grazing lands that once supported an abundance of palatable forage are now almost barren.

Artificial reseeding of range lands has not proven very successful as a whole. Four hundred and fifty different reseeding experiments have been tried on lands of various moisture conditions, topographic features and elevations. The experiments have shown that artificial reseeding is only practical under the following conditions. There are many more or less local areas of considerable acreage in the aggregate, characterized generally by moisture conditions above average and by ample growing season, where artificial reseeding adequately undertaken will justify the expense involved. On denuded areas where erosion has reached an advanced stage, artificial reseeding offers considerable promise toward restoring the grazing capacity. Artificial reseeding cannot yet be made to take the place on any considerable scale of judicious grazing which would result in natural revegetation of depleted range lands. The average mountain range lands susceptible to artificial reseeding will rarely yield a return that will justify an expenditure of more than $3.50 an acre for increasing the grazing capacity, and even the most economical seeding operation cannot meet this figure. (23)

A large number of genera and species of grasses are affected differently by the same environmental factors. That is, the growth and development of one species may be greatly affected by a certain factor, while another growing under the same conditions shows no change. Much work has been done in this field to determine the effect of laboratory conditions, but very little has been done to determine the effect that certain physical and biological factors have on seed germination, and in most of the tests only a small number of genera were used. The majority of the tests that have been carried on by different workers have been with seeds collected from cultivated plants growing under more or less controlled conditions. These tests were made for qualitative purposes alone, to determine as accurately as possible the nature and vigor of the crop that will result from the seeds sown.

C. V. Jackson experimented with a small number of seeds collected on the Jornada Range Reserve in New Mexico. No data were collected concerning the development of the plants from which the seeds were collected. His experiments dealt with only the effects of various laboratory conditions on seed germination. (11)

During the years 1907, 1908, 1909 and 1910, A. W. Sampson carried on some experimental studies on natural revegetation of range lands in the Wallowa Mountains in northeastern Oregon. These studies dealt with the life histories of the more important forage species, including growth requirements and factors influencing the establishment of reproduction. (24)

Accuracy Required

Accuracy is one of the most important factors to be considered in seed testing. It is necessary to insure comparable results, for without it the worker's results are not reliable and in many cases misleading. The men who do the collecting of the seed samples in the field should have a thorough knowledge of the purposes of the germination tests, so that they will secure samples and data that can be relied upon. The identification of all field collections should be checked before samples are tested.

Also, the collector's conception of the seasonal climatic conditions has to be checked against reliable climatalogical data before any conclusions can be safely drawn. Many collectors do not pay very much attention to the amount of precipitation in inches during the growing season and merely guess at the average at the time the seeds are collected. Some consideration has to be given to local conditions, of course, as they quite frequently vary from those taken from the larger sections covered by the various U. S. Weather Bureau station reports.

Probably the most important item affecting the accuracy of any experiment is the plan or system under which the experiment is undertaken, for without a definite system of procedure the worker is lost. The work has to be done step by step in a progressive manner. This fact is as true in the field as in the laboratory.

The necessity of securing several years' results is quite evident. From year to year the plants are subjected to varying conditions which may or may not affect the germination per cent of the seeds they produce. Errors that frequently creep into an experiment are more or less eliminated by a greater number of tests, and several years' data enables one to secure comparable results.

Collection of Samples

The seeds for the germination tests were collected on the eleven National Forests in Montana and Idaho listed above, by the personnel on those Forests. The greater part of the seed collecting was done by the rangers and their assistants, each collection consisting of about one thousand seeds. In addition to the seeds, one entire plant was secured for the purpose of checking the collector's identification. A collector's card was filled out for each sample, which contained such information as the name of the plant from which the seeds were collected, the number of the sample, the name of the forest and the collector, and the factors affecting the development of the plant from which the seeds were collected such as the date of the collection, the elevation, the kind of soil, condition of soil moisture, the range type, the physical condition of the plant, density of vegetation and the extent to which it has been pastured by stock, the amount of rainfall and other factors that might affect the growth and seed producing ability of the plant.

After all of the samples had been collected they were sent to the Regional Office where the identifications were checked. From here the seeds were sent to the testing laboratory of the School of Forestry at the State University of Montana.

Laboratory Equipment

The use of efficient apparatus in the laboratory means quicker and more accurate results. The seed testing laboratory was equipped with special apparatus after the first year, that the germination tests might be carried on more efficiently. The need for this equipment was quite apparent after the first year's experience in seed testing.

At the beginning of the second year of seed testing a special rack was built to hold the porous plates in which part of the experiment was carried on. This piece of equipment was a great improvement over that used the first year, when it had been necessary to place the porous plates on the top of tables while the seeds were germinating. The rack was not only more convenient but made it possible to run tests on twice as many seeds at one time. This rack consisted of a frame two and one-half feet wide, five and one-half feet high and six feet long, containing two tiers of sliding shelves each four inches apart, and was capable of holding one hundred porous plates, thus making it possible to run one hundred germination tests at one time.

An attempt was made the first year to plant a definite number of seeds in the rows in the sand boxes. The seeds were counted out in lots of one hundred and planted in rows, but this method was slow and tedius, and where the seeds were small, many errors were made in the number planted. The second year, in which the present experiment was carried on, a wooden marker was made and used in planting the seeds in the sand boxes. The marker consisted of a strip of wood one-fourth inch thick, two inches wide and as long as the width of the sand boxes. One edge of the marker was divided into one hundred parts, and notches were cut therein to form a like number of teeth. The impression of this edge of the marker in the moist earth of the sand boxes formed one hundred depressions, in each of which one seed was planted. The marker speeded up the process of planting, as well as insuring greater accuracy.

The increase in the number of seed collections received the second year that the tests were run made it necessary to establish a system of filing the glass vials in which the seeds were kept. A filing case was constructed in which the vials containing the seeds were filed, first, under the National Forest from which they were collected, second, under the year in which they were collected, and third, alphabetically according to genera and species.

Sterilizing Equipment

There are several kinds of molds that give considerable trouble in the laboratory, and for this reason, all testing equipment must be sterilized before the tests can be run, in order to eliminate part of the trouble. It is impossible to get rid of the molds entirely as new spores are present on practically all of the seeds tested. It was noted that mold spores seemed to be more numerous on seeds collected from the Brome grasses than on any other.

The porous plates and cover glasses were sterilized in boiling water for twenty minutes prior to each test, in accordance with the rules for seed testing accepted by the Association of Official Seed Analysts of North America. (18) This heat is not sufficient to kill all the spores, but apparently it checked the growth of many as very little mold appeared after the porous plates and cover glasses were sterilized in this manner. The top soil of the sand boxes was sterilized by putting the soil in shallow trays and placing them in an electric oven at a temperature of 200° C. for twenty-four hours.

B. C. Park of the U. S. Forest Service carried on some preliminary studies on the effects of the various molds on seed germination, but did not draw any definite conclusions. He found that where the molds are present in considerable amounts, they do serious damage to the smaller thin-coated seeds. In many cases they entirely consume the seed before it has time to germinate. The molds were found to be more prevalent on seeds collected in wet years than in dry years. (15)

Seed Testing Procedure

Germination and viability tests have been conducted at the School of Forestry of the State University of Montana since 1926. All results of each year's germination tests have been carefully recorded and filed. Seeds have been subjected to approximately the same laboratory conditions, as continuous thermograph records of both soil and air temperatures and daily humidity readings indicate almost uniform conditions throughout the tests. The relative humidity of the laboratory was read and recorded each day with a sling psychrometer, and soil temperatures were taken at a depth of two inches in the sand boxes.

The rules for seed testing that were adopted by the Association of Official Seed Analysts of North America were followed as closely as possible. These rules were written for testing seeds of cultivated plants for the purpose of determining as accurately as possible, before seeds are sown, the nature and vigor of the crop that will result from their use. The rules could not be followed closely in the laboratory where seed testing was carried on with seeds of native grasses and with an entirely different aim in view. (17) (18)

The seeds were first thrashed and all the stems and leaves removed, and immature samples or samples containing only a few mature seeds were discarded. Two lots of one hundred seeds each were counted out from the samples, and each lot was placed in a small vial and labeled with the number corresponding to the laboratory number put on the collector's card for that particular sample. The name of the National Forest, the species and the year collected were also put on the label. The remainder of the seeds were placed in a third vial labeled as before and filed for future reference. The data cards were also filed, so they could be used throughout the tests for recording the germination counts.

Methods of Testing

Sand boxes forty-eight inches long, twenty-four inches wide and seven inches deep were used for making the germination tests, with porous plates used as a check. The lower parts of the boxes were covered with fine sand, on top of which was placed a layer of soil about two inches deep. The seeds were planted in rows of one hundred seeds each, running the width of the boxes, and each row was numbered with the same number as the sample. Prior to planting, the top soil was moistened and made as smooth as possible, and the specially devised marker was used to make the small depressions in which the seeds were planted. The depth of the depressions depended upon the size of the seeds planted. Four such sand boxes were used for these tests.

Germination checks were made in the porous plates at the same time the seeds were tested in the sand boxes. These latter tests were made with seeds from the same samples as those tested in the sand boxes. Lots of one hundred seeds of each species were used in the porous plate tests. Procedure consisted of placing a moist piece of filter paper in the porous plate, which covered the entire surface of the plate. The filter paper was numbered in three places with the same number as occurred on the vial which contained the seeds to be tested on each porous plate. The seeds were placed on one half of the plate only, and the plate was then covered with a cover glass, placed in a tin plate of water and put in the germinating rack.

Regular counts were made of the seeds as they germinated. These counts were made every three or four days during the first part of the test and every seven or eight days during the latter part. To avoid duplication of counts, the germinated seeds were placed on the one-half of the porous plate that had been left blank when the seeds were placed in the plate for the test. As the seeds germinated in the sand boxes, a small white headed pin was placed beside each seedling, and a record of the number of pins placed in each row was kept each time a germination count was made. The tests in the porous plates were run for a period of thirty days, although the greater part of the seeds had completed their germination at the end of twenty days. Some seeds showed no germination at the end of thirty days, and were held over for another period. As soon as the first tests were over, the plates were again sterilized and new samples tested as before.

The germination tests were run for a longer period in the sand boxes than they were in the porous plates. A period of forty days was allowed, but few samples showed any germination after thirty days and many completed their germination from ten to twenty days. Survival counts were made at the end of forty days, the number of each sample still growing at the end of this period being subtracted from the total amount germinated. This gives the total that survive and when expressed in terms of per cent of the total planted gives the survival per cent for any particular species.

This is very important, as it is the total number of seedlings that survive that we are interested in, rather than the total amount that germinate.

It was necessary to water the seeds in the porous plates and sand boxes every day for if they were allowed to become dry at any time during the tests, the results could not be relied upon as being accurate. If the germination were checked by the lack of water after the seeds had begun to germinate, the seedlings would soon die as was the case in one of the earlier tests that was run.

After each germination count was made, the number germinated and the date were recorded on the collector's cards. After the test was completed, the total number of seeds germinated and the total number of days it took to germinate them were recorded in their proper columns. The germination per cent was then figured on the basis of the total number of seeds tested and entered on the data card. The survival per cent was figured for the sand box tests only and entered in separate columns.

A large record sheet was made after all tests were completed for the year. The names of all the genera and species, together with the data on the collector's cards arranged in separate columns directly opposite each other, were entered alphabetically upon this yearly record sheet.

Besides the tests that were made on the present year's samples, tests were also made on a representative group of previous years' samples. The object of these latter tests was to find the effect, if any, of dormancy upon seed germination. Twenty samples from each former year's collections were selected and tested. The germination tests were made in the porous plates only, as the germination per cent was all that was desired. Germination counts were made in the same manner as mentioned before, and the counts and dates were entered in the columns on the collector's cards provided for these data. This information was also entered on the large record sheets in columns that were left blank at the time the original data were compiled.

Over eight hundred seed samples from all the important forage plants of Montana and Idaho were tested, but for the purpose of analysis, the data from only the more important forage grasses is submitted in the following tabulations, where each year's results of samples tested are grouped separately for the purpose of comparison.

With the data from six years' germination tests, the writer has attempted to discover the effect, if any, of pasturage, drouth, elevation, range type, exposure, character of soil, etc., on viability of seeds collected from various range grasses. The effect of dormancy on the germination per cent of grass seeds is also tabulated and discussed in this paper.

TABLE I

The Effect of Different Intensities of Pasturage on Germination Per Cent

Year Tested	SPECIES	Utilization %	Porous Plate Germ. %	Days Germ.	Sand-Box Germ. %	Survival %	Days Germ.
1926	Agropyron caninum	100	2	30	9	9	31
1927		5	70	48	59	59	47
		0	79	35	57	57	34
1928		60	41	14	38	34	26
		100	2	36	16	16	28
1929		20	97	29	40	40	29
		0	87	29	87	87	29
1930		60	39	27	25	18	29
1926	Agropyron smithii	0	72	31	63	63	22
1927		40	49	45	46	36	39
		30	40	45	34	32	39
		65	49	45	45	42	39
1928		30	30	30	47	47	33
		60	27	30	26	26	33
1930		10	0	29	2	2	29
1926	Agropyron spicatum	80	54	14	-	-	-
		50	97	7	87	87	13
		-	67	18	49	49	17
1927		50	92	13	94	88	25
		10	70	25	73	67	30
1928		70	86	30	70	50	17
		95	16	30	29	28	34
		80	85	14	85	69	16
1930		30	100	14	87	70	7
		5	100	11	94	87	29
		20	100	11	94	81	15
1926	Agropyron tenerum	90	74	23	-	-	-
		50	1	31	9	9	44

Year Tested	SPECIES	Utilization %	Porous Plate Germ.%	Days Germ.	Sand Box Germ.%	Survival %	Days Germ.
1927	Agropyron tenerum	80	13	76	53	53	76
		80	36	52	49	44	55
		20	46	41	57	56	32
1928		20	26	30	41	36	46
		60	24	36	2	2	16
		40	25	15	45	37	46
1929		0	87	46	48	41	46
		80	98	29	85	85	29
		35	10	29	40	40	29
1930		0	45	30	39	37	30
		75	78	18	76	68	15
		0	50	12	74	69	35
		30	-	-	21	21	29
1926	Agropyron violaceum	0	85	31	-	-	-
		0	0	30	26	26	31
1927		20	0	69	27	27	50
		40	1	54	27	27	54
1928		70	67	43	25	25	47
		0	72	30	66	64	33
1929		60	5	29	24	24	29
1930		70	7	30	5	5	23
1926	Agrostis hiemalis	0	0	37	0	0	40
1927		65	10	35	13	13	35
1928		80	28	15	16	0	18
1930		55	32	16	20	17	15
1926	Aira caespitosa	35	48	10	55	55	35
1927		45	12	35	12	12	35
1929		0	0	29	2	2	29
1930		60	52	7	24	22	40
1928	Aristida longiseta	20	37	30	10	6	33
1930		20	32	7	9	1	29

Year Tested	SPECIES	Utilization %	Porous Plate Germ. %	Days Germ.	Sand Box Germ. %	Survival %	Days Germ.
1926	Andropogon scoparius	0	0	31	1	1	63
1928		20	2	15	3	3	33
		20	8	25	7	7	26
1929		0	6	29	3	3	29
1926	Bouteloua gracilis	0	23	18	-	-	-
		30	9	11	6	6	25
1927		0	19	7	18	15	14
1930		10	6	15	2	2	29
1926	Bromus marginatus	0	24	22	83	83	14
		0	28	32	32	32	36
1927		75	24	27	17	14	32
		40	34	42	43	43	45
		75	55	62	53	52	11
1928		50	29	37	45	45	30
		80	73	30	69	49	33
		70	66	30	23	23	33
1929		40	87	29	94	94	29
		10	80	29	81	81	29
		0	84	29	81	81	29
1930		10	62	23	57	57	53
		70	38	23	31	29	33
		50	42	31	40	40	36
1927	Bromus polyanthus	80	24	28	22	22	28
1928		80	42	30	35	35	47
		0	83	30	100	100	17
		80	28	43	21	21	47
1929		80	68	29	48	48	29
1926	Bromus tectorum	0	5	32	100	100	8
		0	77	22	93	93	16
1927		0	97	7	97	97	7
		80	99	21	99	99	9
		15	100	10	96	96	9

Year Tested	SPECIES	Utilization %	Porous Plate Germ.%	Days Germ.	Sand Box Germ.%	Survival %	Days Germ.
1928	Bromus tectorum	0	100	9	100	97	10
		70	86	15	79	78	17
		75	97	15	100	100	15
1929		95	100	29	99	99	29
1930		0	98	27	90	80	39
		60	91	18	84	78	11
1926	Bromus porteri	80	76	20	85	85	20
		50	-	-	97	97	14
1927		90	58	44	54	49	69
		0	74	28	88	84	69
		60	82	28	86	79	69
1928		40	63	30	75	73	16
		20	40	25	47	47	37
		0	91	30	88	86	16
1929		20	92	29	100	100	29
		70	93	29	76	76	29
		60	94	29	82	82	29
1930		0	73	23	70	63	30
		40	100	18	94	91	36
		70	100	18	93	85	15
1926	Carex species	50	0	40	0	0	40
		0	4	43	0	0	50
1927		25	0	69	1	1	68
		20	10	40	0	0	48
		30	0	69	3	3	68
1928		30	0	35	1	1	45
		40	2	30	0	0	42
1929		30	0	46	5	4	46
		90	31	29	0	0	29
1930		10	17	36	0	0	45
		10	0	35	4	4	11
1926	Calamagrostis sp.	0	75	17	25	25	55
1927		50	26	55	10	9	65
		0	96	24	2	2	31

Year Tested	SPECIES	Utilization %	Porous Plate Germ.%	Days Germ.	Sand Box Germ.%	Survival %	Days Germ.
1928	Calamagrostis sp.	0	7	30	2	2	30
1926	Danthonia intermedia	0	76	29	5	5	43
		50	22	17	1	1	39
		50	78	22	40	40	34
1927		20	66	66	25	23	59
		25	84	35	24	19	35
1928		0	28	30	26	15	30
		100	4	30	4	4	35
		80	31	42	21	19	39
1929		60	71	46	11	3	46
		80	35	29	6	6	29
1926	Elymus glaucus	0	99	16	93	93	31
		0	96	16	92	92	20
		0	77	28	82	82	15
1927		0	18	44	6	4	14
1928		20	80	25	80	80	26
		20	51	34	22	18	27
		20	94	34	78	78	27
1929		25	52	29	30	29	29
1926	Festuca confinis	0	26	13	28	28	32
1927		20	44	42	39	39	72
1928		80	18	30	6	3	32
1929		30	7	31	1	1	25
1926	Festuca idahoensis	80	67	22	48	48	22
		0	67.	14	70	70	22
		10	34	22	78	78	34
1927		10	68	35	43	42	11
		90	38	12	36	32	22
		90	14	28	18	17	13
1928		70	39	30	28	28	20
		80	45	30	47	27	32
		0	82	30	66	58	30
1929		0	9	29	11	10	29

Year Tested	SPECIES	Utili-zation %	Porous Plate Germ.%	Days Germ.	Sand Box Germ.%	Sur-vival %	Days Germ.
1930	Festuca idahoensis	85	52	25	51	49	15
		20	54	24	39	37	11
1926	Hordeum jubatum	0	31	20	-	-	-
		90	6	10	-	-	-
1927		50	2	7	17	17	86
1930		0	13	21	33	26	25
1926	Hordeum nodosum	10	-	-	6	6	60
1927		85	5	35	32	32	72
		50	-	-	51	51	96
		0	6	54	20	20	54
1928		40	21	30	27	25	30
1930		0	15	35	13	12	39
1926	Koeleria cristata	70	41	21	44	44	23
		0	84	22	63	63	33
		90	38	18	-	-	-
1927		20	39	37	44	41	32
		50	70	25	74	71	23
1928		0	11	15	6	2	32
		75	2	30	6	1	45
1930		30	40	36	24	24	16
1926	Phleum alpinum	80	50	17	64	64	23
		50	92	14	61	61	32
		0	97	11	-	-	-
1927		20	49	45	60	49	42
		0	77	34	59	55	16
		80	17	6	22	18	16
1928		100	35	36	30	29	45
		50	65	36	35	18	45
		0	74	36	69	62	45
1929		20	100	9	82	74	15
		20	81	9	46	39	25
		0	63	29	81	81	29

Year Tested	SPECIES	Utilization %	Porous Plate Germ.%	Days Germ.	Sand Box Germ.%	Survival %	Days Germ.
1930	Phleum alpinum	80	93	25	75	75	26
		10	96	21	90	84	25
1926	Poa pratensis	100	0	29	-	-	-
		0	40	18	70	70	23
		0	73	13	63	63	20
1927		25	53	62	58	54	32
1928		20	40	35	60	60	42
		20	14	35	12	11	36
		80	1	36	4	1	42
1929		90	13	39	8	8	29
		60	49	29	34	33	29
1930		10	87	22	61	61	15
		50	51	35	42	35	15
		0	79	18	50	50	36
1926	Stipa minor	0	0	30	0	0	35
1927		50	1	37	1	1	44
1928		0	1	30	0	0	42
		80	0	30	0	0	30
1929		0	4	29	3	3	29
		40	2	29	3	3	30
1930		0	3	21	1	1	36
		50	2	32	12	40	29
1926	Trisetum spicatum	0	42	11	46	46	16
		80	9	14	30	30	28
1927		70	65	42	59	56	42
1928		50	71	36	72	58	42
		80	44	36	15	9	37
1930		40	27	35	38	36	20

The per cent a range is utilized has some effect upon the germination per cent of many genera and species of grasses. That is, if over-utilization is practiced for several years in succession, a change can be noted in the germination per cent of many species. In able I the majority of the samples tested was not collected from the same location each year, and little or no data on past utilization were recorded. Had this been done, an accurate check could have been obtained. For this reason, the following results only indicate that over-utilization has affected the germination per cent of the seeds. (24)

Two samples of _Agropyron caninum_ that were tested, where the utilization was one hundred per cent or slightly below, showed germination per cents of thirty-two per cent and twenty-five per cent below the average of the five years' tests.

No conclusions could be drawn on germination tests run on _Agropyron spicatum, smithii_ and _violaceum_, since such variations occurred in germination per cent and in no case was utilization above eighty per cent. The low germination per cents of _Agropyron smithii_ and _violaceum_ in 1930 were probably due to drouth conditions rather than the per cent of utilization.

The degree to which an area is grazed for one or two years apparently has no effect on the germination per cent of *Agropyron tenerum.* The samples collected on areas where the utilization was above eighty per cent showed an average germination per cent equaling that of those collected on areas where the utilization per cent was below eighty. Here again in 1930 the low germination per cent was probably due to drouth conditions.

Germination per cents of species of *Agrostis, Aira, Aristida* and *Andropogon* do not appear to have any relation to the utilization per cent, as low germination per cent occurred as frequently among those samples that were collected where the utilization was high as where it was low.

The tests run on *Bouteloua gracilis* indicated that an increased utilization per cent decreased the germination per cent. The drouth condition that prevailed during the year of 1930 was probably the cause of the low germination per cent for that year.

The germination tests show no material change in germination per cent of seeds of *Bromus marginatus, polyanthus* and *porterii* due to over or under utilization. With *Bromus tectorum* an increase in utilization appears to have increased the germination per cent above the average in several cases. This condition could have been due to the stimulating influence that over-grazing would have. This species, more commonly known as "cheet grass", grows very densely and therefore any opening up of the stand due to over-grazing could be the cause of the production of more viable seeds by this grass.

Species of _Carex_ showed no change in germination per cent due to different intensities of grazing.

Different intensities of grazing showed no influence on germination per cents of _Caamagrostis_, _Elymus_ and _Koeleria cristata_.

The germination per cent of _Danthonia intermedia_ was lowered as much as seventy-five per cent where utilization was over eighty per cent. Species of _Festuca_ were affected likewise by an increase in utilization, but to a lesser degree.

Hordeum jubatum and _nodosum_ showed a marked decrease in germination per cent due to greater utilization.

The germination per cent of _Phleum alpinum_ and _Poa pratensis_ was equally reduced by high utilization per cent.

No change in the germination per cent of _Stipa minor_ was recorded where utilization played any part. No tests were above four per cent.

All samples of _Trisetum spicatum_ where utilization per cent was above eighty per cent showed a marked decrease in germination per cent.

TABLE II

The Effect of Elevation on the Germination Per Cent

Year Tested	SPECIES	Elevation Collected	Porous Plate Germ.%	Days Germ.	Sand Box Germ.%	Survival %	Days Germ.
1927	Agropyron caninum	6500	79	35	57	57	54
		7800	52	55	66	63	45
1928		5100	41	14	38	34	26
		8000	36	16	16	16	28
1929		4600	87	29	87	87	29
		9200	36	29	57	57	29
1926	Agropyron smithii	4800	72	31	63	63	22
		8000	2	10	-	-	-
1927		8500	33	69	31	31	54
		6000	49	45	45	42	39
1928		3000	30	30	47	47	33
		7600	4	30	6	6	34
1926	Agropyron spicatum	8000	-	-	49	49	17
		5800	96	38	96	96	38
		2500	97	7	87	87	13
1927		5300	92	13	94	98	25
		4000	70	25	73	67	30
1928		7500	86	30	70	50	17
		8000	85	14	85	67	16
1930		5000	100	14	87	70	7
		5500	100	11	94	87	29
1926	Agropyron tenerum	5800	74	23	-	-	-
		8000	1	31	9	9	44
		8000	2	16	8	8	46
1927		5300	46	41	57	56	32
		7800	1	44	10	10	38
1928		5100	25	15	45	37	46
		7000	24	36	2	2	16
1929		9600	1	29	11	10	29
		5300	87	46	48	41	46

Year Tested	SPECIES	Elevation Collected	Porous Plate Germ.%	Days Germ.	Sand Box Germ.%	Survival %	Days Germ.
1930	Agropyron tenerum	8600	0	30	0	0	30
		6600	45	30	39	37	30
1926	Agrostis species	7300	10	16	5	5	13
		5000	0	31	-	-	-
1927		5300	2	55	2	2	55
		7200	10	35	13	13	35
1928		8500	62	15	-	-	-
		5500	0	34	0	0	36
1929		8500	57	29	56	56	29
1930		4700	8	21	3	3	29
		5400	32	16	20	17	15
1926	Bouteloua gracilis	4000	9	11	6	6	25
1927		3500	19	7	18	15	14
1930		3900	6	15	2	2	29
1926	Bromus marginatus	6700	-	-	76	76	31
		7500	24	22	83	83	14
		4500	28	32	32	32	36
1927		3500	0	65	15	15	35
		7800	9	45	32	32	55
		6800	55	62	53	52	11
1928		9000	29	27	45	45	30
		6500	15	30	36	36	33
		7200	73	30	69	49	33
		5500	33	35	28	28	27
1929		8600	87	29	94	94	29
		8000	80	29	81	81	29
		4000	50	46	50	50	46
1930		7000	42	31	40	40	36
		6000	20	24	23	23	35
		7000	1	41	59	59	41
1926	Bromus porteri	5800	0	43	81	81	18
		5400	-	-	97	97	14
		1542	26	20	85	85	20

Year Tested	SPECIES	Elevation Collected	Porous Plate Germ.%	Days Germ.	Sand Box Germ.%	Survival %	Days Germ.
1927	Bromus porteri	6500	74	28	88	84	69
		8600	82	28	86	79	69
		5600	88	35	90	87	45
1928		6500	63	30	75	73	16
		3000	40	25	47	47	37
		8000	91	30	88	86	16
1929		4000	92	29	100	100	29
		8700	93	29	76	76	29
		6600	94	29	82	82	29
1930		6200	100	18	93	85	15
		7200	100	18	94	91	36
1926	Bromus tectorum	4500	-	-	100	100	8
		3000	77	22	93	93	16
1927		6800	99	21	99	98	9
		6000	100	10	96	96	9
1928		5750	97	15	100	100	15
		8500	91	30	84	84	33
		6000	100	9	100	97	10
1929		7000	100	29	99	99	29
1930		5500	98	27	90	80	39
		6500	91	18	84	78	11
1926	Calamagrostis sp.	6400	75	17	25-	25	55
1927		5300	26	25	55	10	9
		6000	96	24	-	-	-
1928		6200	7	30	2	2	30
1926	Danthonia intermedia	6000	76	29	5	5	43
		7300	22	17	1	1	39
		5000	1	13	0	0	40
1927		6000	66	66	25	23	50
		6800	84	35	24	19	35
1928		6400	28	30	26	15	30
		9000	4	30	4	4	35
		7500	10	30	10	8	30
1929		6700	35	19	6	6	29
		7500	71	46	11	3	46

Year Tested	SPECIES	Elevation Collected	Porous Plate Germ.%	Days Germ.	Sand Box Germ.%	Survival %	Days Germ.
1926	Festuca idahoensis	8000	67	22	48	48	22
		3500	67	14	70	70	22
		3600	-	-	77	77	29
1927		5300	68	35	43	42	11
		7000	38	12	36	32	22
		7500	68	33	52	49	25
		3500	92	19	78	75	30
1928		5400	82	30	66	58	30
		8500	67	30	45	36	30
		6600	33	30	3	27	32
1929		8900	52	25	51	49	15
		7700	46	23	38	37	23
		3800	39	32	38	33	29
1926	Festuca confinis	7000	26	13	28	28	32
1927		6800	44	42	39	39	72
1928		8200	18	30	6	3	32
		6300	10	30	4	4	36
1930		6500	7	31	1	1	25
1926	Hordeum jubatum	4600	4	14	-	-	-
		5800	6	10	-	-	-
1927		5300	2	7	17	17	86
1930		5500	13	31	33	26	25
1926	Hordeum nodosum	7300	0	32	6	6	60
1927		7000	5	35	32	32	72
1928		6600	21	30	27	25	30
1930		8600	15	35	13	12	39
1926	Koeleria cristata	3500	87	8	46	46	31
		8000	15	-	36	36	20
1927		3700	70	25	74	71	23
		5300	39	37	44	41	32
1928		6600	2	30	6	1	45
1930		7000	40	36	24	24	16

Year Tested	SPECIES	Elevation Collected	Porous Plate Germ.%	Days Germ.	Sand Box Germ.%	Survival %	Days Germ.
1926	Phleum alpinum	7000	85	13	82	82	21
		5300	92	14	61	61	32
		8500	95	7	88	88	32
		4200	97	11	-	-	-
1927		9400	49	45	60	49	42
		8000	78	22	34	31	34
		6500	77	34	59	55	16
1928		7500	79	15	39	28	18
		8500	65	36	35	18	45
		6200	88	34	75	74	37
1929		6500	100	9	82	74	15
		6500	81	9	46	39	25
		9000	63	29	81	81	29
		9000	68	29	66	64	29
1930		6600	50	23	41	41	30
		8500	93	25	75	75	26
		8200	96	21	90	84	25
1926	Poa pratensis	7000	59	14	18	18	24
		6000	73	13	63	63	20
		5800	91	11	75	75	31
1928		6800	46	35	66	60	42
		6500	14	35	12	11	36
1929		6800	13	29	8	8	29
		3700	49	29	34	33	29
1930		5000	87	22	61	61	15
		7000	51	35	42	35	15
1926	Stipa minor	6600	-	-	-	-	-
1927		5300	1	37	1	1	44
1928		9000	1	30	0	0	42
		6000	5	36	10	1	42
1929		6000	0	25	9	4	36
		6600	4	29	3	3	29
1930		7000	0	30	3	3	31
		5600	3	21	1	1	35
		3800	2	32	12	4	29

Year Tested	SPECIES	Elevation Collected	Porous Plate Germ.%	Days Germ.	Sand Box Germ.%	Survival %	Days Germ.
1926	Trisetum spicatum	4000	42	11	46	46	16
		6875	9	14	30	30	20
1928		5200	51	34	34	32	37
		8500	44	36	15	9	37
1930		8800	27	35	38	36	20

It will be seen in Table II that the fertility of some seeds appears to decrease with elevation, while others show the opposite effect. The elevations at which the seeds were collected were divided into two zones, those above six thousand feet being grouped together into one zone and those below six thousand feet into the second zone. Germination per cents for twenty grasses were recorded for each of the two zones. The plants of high zone showed an average germination of forty-five per cent as against fifty-five per cent for those of the lower zone. The difference of ten per cent in germination is not sufficient to warrant drawing any definite conclusions.

Three grasses, Agrostis species, Bromus marginatis and Bromus porterii showed an increase in germination with an increase in elevation. The germination of Bromus tectorum apparently was not affected by elevation as the average germination per cent for high and low zones was the same.

No samples were collected on high zones for Bouteloua _gracilis_ and _Hordeum jubatum_ and none on low zones for _Festuca confinis_ and _Hordeum nodosum_, and therefore no comparisons could be drawn.

TABLE III

The Effect of Drouth on Germination Per Cent

Year Tested	SPECIES	Moisture Condition Seasonal	Porous Plate Germ.%	Days Germ.	Sand Box Germ.%	Sur-vival %	Days Germ.
1927	Agropyron caninum	AboveNormal	79	35	57	57	54
		AboveNormal	48	41	63	63	32
1928		Normal	41	14	38	34	26
		Normal	-	-	16	16	28
1929		Dry	92	29	84	84	29
		Dry	87	29	87	87	29
		Dry	92	29	85	84	29
1930		Dry	39	27	25	18	29
1926	Agropyron smithii	Normal	72	31	63	63	22
1927		AboveNormal	49	45	46	36	39
		AboveNormal	49	45	45	42	39
1928		Normal	30	30	47	47	33
		Normal	27	30	26	26	33
1930		Dry	0	29	2	2	29
1926	Agropyron spicatum	Normal	96	38	96	96	38
		Normal	97	7	87	87	13
1927		AboveNormal	92	13	94	88	25
		AboveNormal	70	25	73	67	30
1928		Normal	86	30	70	50	17
		Normal	85	14	85	69	16
1930		Dry	100	14	87	70	7
		Dry	100	11	94	87	29
1926	Agropyron tenerum	Normal	1	31	9	9	44
		Normal	2	16	8	8	46
1927		AboveNormal	13	76	53	53	76
		AboveNormal	36	52	49	44	55
1928		Normal	26	30	41	36	36
		Normal	8	30	16	15	33
1929		Dry	-	-	12	12	14
		Dry	10	29	40	40	29

Year Tested	SPECIES	Moisture Condition Seasonal	Porous Plate Germ. %	Days Germ.	Sand Box Germ. %	Sur-vival %	Days Germ.
1930	Agropyron tenerum	Dry	45	30	39	37	30
			-	-	37	37	40
1926	Agrostis species	Normal	10	16	5	5	13
1927		AboveNormal	10	35	13	13	35
			2	55	2	2	55
1928		Normal	28	15	18	0	18
			62	15	4	4	32
			0	34	0	0	36
1929		Dry	57	29	56	56	29
1930		Dry	32	16	20	17	15
			8	21	3	3	29
1926	Bouteloua gracilis	Normal	23	18	-	-	-
			9	11	6	6	25
1927		AboveNormal	19	7	18	15	14
1930		Dry	6	15	2	2	29
1926	Bromus marginatus	Normal	24	22	83	83	14
			28	32	32	32	36
			-	-	76	76	31
1927		AboveNormal	9	45	32	32	55
			24	27	17	14	32
			34	42	33	43	45
1928		Normal	29	37	45	45	30
			15	30	36	36	33
1929		Dry	87	29	94	94	29
			80	29	81	81	29
			84	29	81	81	29
1930		Dry	62	23	57	57	23
			-	-	59	59	41
1926	Bromus porteri	Normal	76	20	85	85	20
			-	-	97	97	14
			-	-	81	81	13
1927		AvoveNormal	74	28	88	84	69
			82	28	86	79	69
			88	35	90	87	45

Year Tested	SPECIES	Moisture Condition Seasonal	Porous Plate Germ.%	Days Germ.	Sand Box Germ.%	Survival % ,	Days Germ.
1928	Bromus porteri	Normal	63	30	75	73	16
			91	30	88	86	16
			56	30	69	68	35
1929		Dry	92	29	100	100	29
			93	29	76	76	29
			91	46	94	92	46
1930		Dry	100	18	94	91	36
			100	18	93	85	15
1926	Bromus tectorum	Normal	-	-	100	100	8
			77	32	93	93	16
1927		AboveNormal	97	7	97	97	7
			99	21	99	98	9
			100	10	96	96	9
1928		Normal	100	9	100	97	10
			97	15	100	100	15
			91	30	84	84	33
1929		Dry	100	29	99	99	29
1930		Dry	98	27	90	80	39
			91	18	84	78	39
1926	Calamagrostis sp.	Normal	75	17	25	25	55
1927		AboveNormal	26	55	10	9	65
			96	24	2	2	31
1928		Normal	7	30	2	2	30
1930		Dry	0	30	2	2	29
1926	Danthonia intermedia	Normal	76	29	5	5	43
			22	17	1	1	39
1927		AboveNormal	66	66	25	23	59
			84	35	24	19	35
1928		Normal	28	30	26	15	30
			31	42	21	19	39
1929		Dry	1	46	0	0	46
			35	29	6	6	29
1926	Festuca idahoensis	Normal	67	22	48	48	22
			67	14	70	70	22
			82	48	50	50	45

Year Tested	SPECIES	Moisture Condition Seasonal	Porous Plate Germ.%	Days Germ.	Sand Box Germ.%	Sur-vival %	Days Germ.
1926	Festuca idahoensis	Normal	67	22	48	48	22
			67	14	70	70	22
			82	48	50	50	45
1927		AboveNormal	46	17	53	48	22
			68	33	52	49	25
			73	37	64	63	21
1928		Normal	70	43	75	72	24
			85	15	77	75	48
			45	30	47	27	32
1929		Dry	9	29	11	10	29
1930		Dry	52	25	51	49	15
			54	24	39	37	11
			39	32	38	33	29
1926	Festuca confinis	Normal	26	13	28	28	32
1927		AboveNormal	44	42	39	39	72
1928		Normal	18	30	6	3	32
			10	30	4	4	36
1930		Dry	7	31	1	1	25
1926	Hordeum jubatum	Normal	4	14	-	-	-
			6	10	-	-	-
			-	-	4	4	48
1927		AboveNormal	2	7	17	17	86
1930		Dry	13	21	33	26	25
			-	-	7	7	20
1926	Hordeum nodosum	Normal	0	32	6	6	60
1927		AboveNormal	5	35	32	32	72
			6	54	20	20	54
1928		Normal	21	30	27	25	30
1930		Dry	15	35	13	12	39
1926	Koeleria cristata	Normal	84	22	63	63	33
			38	18	-	-	-
			50	8	-	-	-

Year Tested	SPECIES	Moisture Condition Seasonal	Porous Plate Germ.%	Days Germ.	Sand Box Germ.%	Sur-vival %	Days Germ.
1927	Koeleria cristata	AboveNormal	39	37	41	44	32
			70	25	74	71	23
1928		Normal	11	15	6	2	22
			2	30	6	1	45
1930		Dry	3	15	3	3	36
			40	36	24	24	16
1926	Phleum alpinum	Normal	85	13	82	83	21
			92	14	61	61	32
			95	7	88	88	32
1927		AboveNormal	78	22	34	31	34
			77	34	59	55	16
			49	45	60	49	42
1928		Normal	79	15	39	28	18
			65	36	35	18	45
			74	36	69	62	45
			88	34	75	74	37
1929		Dry	63	27	81	81	29
			7	29	62	62	29
			68	29	66	64	29
			40	29	82	82	29
1930		Dry	50	43	41	41	30
			93	25	75	75	26
			96	21	90	84	25
1926	Poa pratensis	Normal	91	11	75	75	31
			40	18	70	70	23
			73	13	63	63	20
1927		AboveNormal	53	62	58	54	32
1928		Normal	17	36	7	4	42
			14	35	12	11	36
1929		Dry	13	29	8	8	29
			49	29	34	33	29
1930		Dry	42	13	41	38	15
			51	35	42	35	15
			67	11	34	30	12

Year Tested	SPECIES	Moisture Condition Seasonal	Porous Plate Germ.%	Days Germ.	Sand Box Germ.%	Sur-vival %	Days Germ.
1927	Stipa minor	AboveNormal	1	37	1	1	44
1928		Normal	1	30	0	0	42
			1	36	1	1	45
			5	36	10	1	42
1929		Dry	0	25	9	4	36
			.1	29	11	11	29
			4	29	3	3	29
1930		Dry	0	30	2	3	31
			3	21	1	1	35
			2	32	12	4	29
1926	Trisetum spicatum	Normal	42	11	46	46	16
			9	14	30	30	28
1927		AboveNormal	65	42	59	56	42
1928		Normal	51	34	34	32	37
			71	36	72	58	42
1930		Dry	27	35	38	36	20

Table III was made to show the effect that the grazing type in which the sample was collected might have on its germination per cent. The table was built upon averages, that is, germination tests for years with average precipitation or above were grouped separately from those years where the precipitation was below average. The majority of the samples was collected on open grassland areas and no definite conclusions can safely be drawn on this particular phase of the experiment.

In a number of cases an increase in germination per cent was recorded for samples collected under timber in the dry seasons of 1929 and 1930, and in a less number of cases where the samples were collected in sagebrush areas. The conservation of moisture by the over-story of timber and sage could easily be the cause of the increase in the germination.

TABLE IV

The Effect of Grazing Type on Germination Per Cent

Years Tested Average	SPECIES	GRASS Porous Plate Germ.%	GRASS Sand Box Germ.%	TIMBER P.P. G.%	TIMBER S.B. G.%	WEED P.P. G.%	WEED S.B. G.%	SAGE P.P. G.%	SAGE S.B. G.%
*1926-27-28	Agropyron caninum	50	56	41	38				
*1929-30		64	55			88	86		
1926-27-28	Agropyron smithii	35	34	32	28				
1929-30		0	2						
1926-27-28	Agropyron spicatum	65	60					52	43
1929-30		87	78						
1926-27-28	Agropyron tenerum	42	30					6	11
1929-30		61	50						
1926-27-28	Agrostis species	25	15						
1929-30		46	34						
1926-27-28	Bouteloua gracilis	17	12						
1929-30		6	2						
1926-27-28	Bromus marginatus	37	45	28	32	–	15	15	36
1929-30		40	47	80	81			62	57
1926-27-28	Bromus porteri	58	70					70	78
1929-30		90	85					87	83
1926-27-28	Bromus tectorum	87	87					92	92
1929-30		96	91						
1926-27-28	Calamagrostis species	40	9						
1929-30		0	2						

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* 1926-27-28: Years of normal or above normal precipitation

1929-30: Years with below normal precipitation

Years Tested Average	SPECIES	GRASS Porous Plate Germ.%	GRASS Sand Box Germ.%	TIMBER P.P. G.%	TIMBER S.B. G.%	WEED P.P. G.%	WEED S.B. G.%	SAGE P.P. G.%	SAGE S.B. G.%
1926-27-28	Danthonia intermedia	14	30					53	13
1929-30		33	11	7	7				
1926-27-28	Festuca idahoensis	50	45	66	80			56	53
1929-30		33	29	38	39			38	37
1926-27-28	Festuca confinis	29	19						
1929-30		7	1						
1926-27-28	Hordeum jubatum	6	10						
1929-30		13	20						
1926-27-28	Hordeum nodosum	10	27						
1929-30		15	13						
1926-27-28	Koeleria cristata	41	33	21	25			24	10
1929-30		21	14						
1926-27-28	Phleum alpinum	65	43	70	69				
1929-30		56	67	81	65				
1926-27-28	Poa pratensis	50	30	34	52				
1929-30		58	40	60	51	51	42		
1926-27-28	Stipa minor	3	2						
1929-30		5	2	3	6			10	8
1926-27-28	Trisetum spicatum	47	40						
1929-30				27	38				

TABLE V

The Effect of Dormancy on Germination Per Cent

Year Collected	SPECIES	YEAR TESTED 1926 Germ.%	1927 Germ.%	1928 Germ.%	1929 Germ.%	1930 Germ.%
1926	Agropyron smithii	72		96		96
1928				30		15
1929	Agropyron caninoides				97	81
1927	Agropyron caninum		42		52	45
1929					92	16
1926	Agropyron spicatum	67			32	38
1927			70		65	46
1928				86		36
1927	Agropyron tenerum		46		82	83
1928				26		52
1929					98	61
1927	Agropyron violaceum		1		7	12
1928				72		80
1929					5	37
1927	Agrostis hiemalis		10		87	90
1928				62		74
1928	Andropogon scoparius			8		6
1929					6	5
1926	Bromus marginatus	24			30	62
1927			20		35	44
1928				73		58
1929					87	74

Year Collected	SPECIES	YEAR TESTED 1926 Germ.%	1927 Germ.%	1928 Germ.%	1929 Germ.%	1930 Germ.%
1926	Bromus porteri	25	....	....	70	....
1927		....	88	....	93	44
1928		....	....	91	....	88
1929		....	....	....	93	77
1928	Bromus polyanthus	....	....	83	....	80
1929		....	....	....	69	65
1926	Bromus richardsonii	60	....	....	95	94
1927	Bromus tectorum	....	100	....	100	100
1928		....	....	100	....	100
1929		....	....	....	100	100
1927	Bouteloua gracilis	....	19	....	11	23
1926	Carex species	0	....	....	74	67
1926		0	....	....	46	53
1927		....	0	....	0	8
1928		....	....	0	....	0
1928		....	....	1	....	1
1929		....	....	....	0	0
1926	Danthonia intermedia	76	....	....	73	100
1927		....	7	....	8	51
1928		....	....	28	....	31
1929		....	....	....	35	38
1929	Elymus glaucus	....	....	....	52	27
1928	Festuca confinis	....	....	18	....	33
1926	Festuca idahoensis	67	....	....	49	57
1926		0	....	....	....	43

Year Collected	SPECIES	YEAR TESTED 1926 Germ.%	1927 Germ.%	1928 Germ.%	1929 Germ.%	1930 Germ.%
1927	Festuca idahoensis	....	79		 83	 28
1928		....	....	82		 28
1929		....	....		 9	 22
1926	Festuca scabrella	15	....		 12	 23
1926		11	....		 36	 38
1827		....	60		 40	 24
1928		....	....	45		 38
1929		....	....		 71	 47
1927	Hordeum nodosum	0	....	....		 58
1926	Koeleria cristata	15	....		 50	 47
1927		....	70		 43	 33
1928		....	....	11		 10
1929	Melica spectabilis	....	....		 0	 1
1926	Muhlenbergia species	0	....		 7	 7
1928		....	....	0		 4
1926	Phleum alpinum	95	....		 95	 98
1927		....	77		 81	 99
1928		....	....	79		 81
1929		....	....		100	100
1926	Poa species	59	....		 60	 58
1926		85	....		 79	 66
1927		....	53		 86	 48
1928		....	....	46		 32
1929		....	....		 7	 33
1929		....	....		 13	... 22

Year Collect-ed	SPECIES	YEAR TESTED 1926 Germ.%	1927 Germ.%	1928 Germ.%	1929 Germ.%	1930 Germ.%
1927	Stipa comata		13			27
1927	Stipa minor		1			48
1928				5		55
1929					0	20
1928	Stipa viridula			4		42
1926	Trisetum spicatum	42			66	16
1927		65			100	65

Table V illustrates that samples of *Stipa minor* collected and tested in 1927, 1928 and 1929 showed germination per cents of one, five and zero respectively. Seeds from the samples tested in 1930 showed germination per cents of forty, fifty-five and twenty. This large increase in germination was also true for other species of *Stipa*, *Muhlenbergia*, *Hordeum*, *Carex*, and *Agrostis*. The germination of *Danthonia intermedia*, *Bouteloua gracilis*, *Melica spectabilis Phleum alpinum*, *Trisetum spicatum* and *Agropyron violaceum* was likewise increased but to a lesser degree. Many seeds require a rest period before good germination can be expected. (27) This probably accounts for the increase in germination seen in Table V.

The above germination tests represent the effects that storage in the laboratory have on germination per cent. Field storage would doubtless have different effects.

TABLE VI

The Effect of Exposure on Germination Per Cent

Source of Seed	Altitude	Germination
South exposure	6000-7500	43.0
North exposure		37.0
East exposure		33.0
West exposure		39.0

As seen in Table VI, exposure seems to have only a slight effect on germination per cent. The results in this table correspond very closely to those obtained by Sampson in his test on the effect of exposure and the date of seed maturity on seed germination. (24)

DISCUSSION

The influence that certain physical and biological factors have on plant growth is reflected in the viability of the seeds they produce, which in most cases is their only method of propagation. According to authorities and the author's observation in the field not all plants are affected alike by the same environmental factors. In many instances, in an association of plants, one or two will show pronounced changes in growth, due to the presence of some abnormal factor as drouth, over-grazing, etc. (24) (19)

It can be seen from the foregoing data that plants prefer certain types of soils, exposures and elevations in preference to others. They seem to produce a greater number of viable seeds on the sites they prefer. The variation that occurred in the germination per cent of any species could in part be credited to this fact, since the seeds were collected from numerous sites.

Although the results obtained in this experiment were based upon a large number of seeds collected from a wide range of habitats and for five years in succession, my deductions certainly cannot be conclusions until complete data on the growth of the plant from which the seed is collected are recorded for each year, and also in order to draw any definite conclusions, the seed should be collected from the same plots each year.

The fact that many seeds require a rest period before they show complete germination has helped to regenerate ranges after drouth periods, during which no seeds are produced.

RECOMMENDATIONS FOR FURTHER STUDY

The more important requirements for further progress on this problem are:

1. Development of a more systematic method for collecting seeds in the field. A large number of plots should be established upon which the seeds should be collected each year. These plots should be established on as many different sites and elevations as possible, and each species should be collected on various sites and elevations, for the purpose of comparing germination per cents accurately.
2. Determination of the date of maturity of every individual sample collected, as the date of seed maturity has an influence on germination per cent of many seeds.
3. To provide for at least five years, and more if possible, to complete the experiment.

These objectives can only be achieved by a well planned and adequately financed program of investigation and experimental work.

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